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DEPARTMENT OF THE INTERIOR

J. A KRUG, Secretary

GEOLOGICAL SURVEY

W E. WRATHER, Director

PROGRESS REPORT ON GROUND-WATER CONDITIONS

[redacted]

By

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ABSTRACT

The Cortland area is a part of the Susquehanna River drainage basin and the Appalachian Plateaus physiographic province. It is a maturely dissected plateau of moderate relief. The climate is characterized by warm summers and moderately severe winters. Approximately one-fourth of the mean annual precipitation of 37.92 inches ordinarily is received in the spring, when most ground-water recharge occurs.

The city of Cortland is the center of population of the area and is located at the junction of several broad and gently sloping valleys. Situated here are a number of industries which over a period of years have had a consistent growth in size and importance. The villages of Homer and McGraw are contiguous to Cortland and form a part of its general business area. Agriculture, especially dairying, is an important occupation in the quadrangle.

The bedrock is Devonian in age and includes strata ranging from the Hamilton group to the Chemung formation. The strata lie nearly horizontal and show little disturbance. It is believed that only small to moderate supplies of water may be pumped from the bedrock. Even the sandstones have a texture which gives them low specific yield and permeability.

The entire region has been glaciated. The most prominent effects of glaciation are shown in the broad valleys, which have been deepened and widened by the ice. These valleys have been filled with roughly sorted outwash deposits and contain an abundance of ground water.

The discussion of ground-water conditions is based on records

of 97 wells. Records are included for the wells of three public-supply systems and for many industrial and domestic wells. Also, a hydrograph of an observation well located within the quadrangle is included to show the fluctuation of the water table under natural conditions. A number of water analyses are included to show the quality of the water and its suitability with respect to utilization. The mineral quality was found in nearly all cases to be entirely satisfactory for most purposes. The temperature of ground water, which is constant and is considerably lower than that of surface water in the summer, makes it very desirable for industrial uses involving cooling. The total amount of ground water recovered daily in the Cortland quadrangle is estimated to be about 5 million gallons, 4 million gallons of which is used in Cortland and Homer for industrial and public water supply. Most of the work was done in the valley areas where drilled and driven wells ending in outwash deposits of sand and gravel are generally used. In the uplands, ground water is commonly recovered through springs, shallow dug wells, and wells drilled in rock. A sufficient supply of ground water for domestic needs may be obtained anywhere in the quadrangle from the bedrock formations. Large supplies are recovered only from the sand and gravel deposits. Relatively large quantities of ground water can be obtained throughout nearly all the broad valleys of the Cortland quadrangle, and the area is capable of vastly greater development than has been made to date.

INTRODUCTION

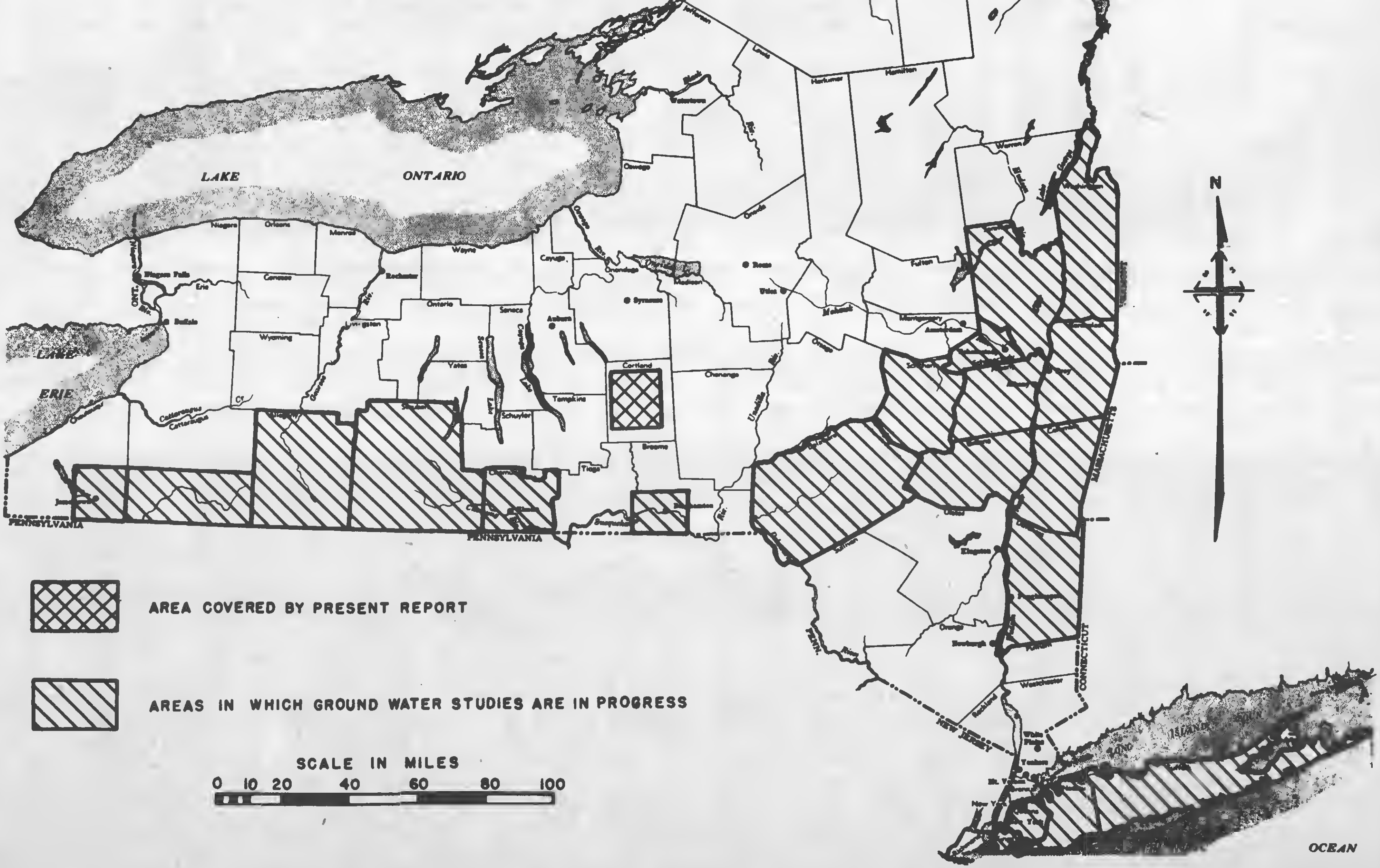
Purpose and scope of the investigation

In April 1945 the U. S. Geological Survey began an investigation of the ground-water resources of the State of New York in cooperation with the New York Water Power and Control Commission. The investigation is also sponsored actively by the New York Department of Commerce, the New York Department of Conservation, the New York Department of Health, the New York State Museum, and the State Geologist. The program involves, first, a systematic areal survey of the entire State, to locate sources of ground-water supplies and to determine their quality and quantity; and second, the collection of data that will promote the conservation of these ground-water resources. Coverage of the State will be on the basis of seven areas consisting of eight to ten counties each. The first area being worked is in and around the Capitol District, and preliminary information is being obtained by reconnaissance in a number of other regions, particularly throughout the southern tier of counties (fig. 1).

The present report is the result of a preliminary survey of a portion of Cortland County. A more detailed investigation covering the entire area of Cortland County as well as adjacent counties will be made at a later time and the data obtained will be incorporated in a more comprehensive report. The Cortland quadrangle was chosen for reconnaissance because general information indicated that considerable ground water of good quality was pumped for public supply and for industrial purposes, and because of the lack of readily accessible information regarding ground-water supplies made it desirable

FIGURE 1

INDEX MAP OF NEW YORK



to provide such data for future industrial expansion in the area. The investigation was concentrated in the broad valley areas, where the thick deposits of highly permeable outwash furnish the only large supplies of ground water in the quadrangle and where the chief ground-water demands of population and industry exist.

Acknowledgments

Part of the well records given in this report were collected by Henry Paige in August and September 1945. The remainder were collected by the writer during two weeks of field work in December 1945. Appreciation is due to many persons and agencies who contributed information and services. Among these are the New York State Department of Public Health, which analyzed water samples, the New York State Museum, the New York Water Power and Control Commission, and the New York State Department of Commerce. Mr. Russell Suter, Executive Engineer, New York Water Power and Control Commission, read the manuscript and kindly offered many helpful suggestions. Acknowledgment is also made to the various well drillers and well owners whose contributions of information form an important part of this report. The work was done under the supervision of M. L. Brashears, Jr., district geologist in charge of the ground-water investigations of the U. S. Geological Survey in New York and New England.

The area

The Cortland quadrangle is situated in west-central Cortland County and lies between 76° 00' and 76° 15' west longitude and 42° 30' and 42° 45' north latitude. It is in the central portion of the State, about half way between Syracuse and Binghamton and approximately 20 miles northeast of Ithaca.

The Cortland quadrangle is in the Susquehanna River drainage basin with the exception of the extreme northwest and southwest corners, where the Skaneateles Inlet and Virgil Creek regions are included in the St. Lawrence River system. The principal stream is the Tioughnioga River (pl. 1). The East Branch rises in Madison County and flows southwest to Cortland. The West Branch rises in the extreme southern part of Onondaga County and flows in a southerly direction to Cortland, where the two branches unite. From this point the general course of the Tioughnioga River is southeast across the southern half of the area. It is the chief tributary of the Chenango River and flows into it approximately 15 miles beyond the southern border of the quadrangle.

In the immediate vicinity of Cortland the valleys of several fairly large streams, in addition to those of the East and West Branches of the Tioughnioga, converge to form a broad plain several miles in extent. The valleys are broad, with the exception of those of Trout Brook and the Tioughnioga River south of Blodgett Mills, and all have flat, gently

sloping floors. The elevation of the valley flats ranges from 1,180 feet above sea level at the northern border of the quadrangle to 1,050 feet above sea level in the extreme southern part of the quadrangle, giving an average gradient of roughly 5 or 6 feet per mile.

The land rises, often with considerable abruptness, from the valleys into the numerous rounded hills. The amount of relief is fairly uniform over the region, and the average altitude of the summits is in the neighborhood of 1,800 to 1,900 feet. The greatest elevation occurs in the south, where the hills rise nearly 1,000 feet above the Tioughnioga River.

This hill country is a dissected plateau of moderate relief in a mature stage of erosion. It belongs in the Southern New York section of the Appalachian Plateaus physiographic province.

Cultural aspects

The city of Cortland, the county seat, is in the west-central portion of the quadrangle--the area of densest population. Its situation on a plain at the junction of several large valleys is probably responsible for its growth and importance (pl. 1). The total population of the city was listed as 23,836 in the 1940 census. An estimated 98 percent of the population is served by the municipally owned water system, which obtains water from wells. Cortland is a trading center for an estimated suburban population of about 75,000. It has a municipal airport and is served by two trunk-line railroad systems; the Elmira, Cortland and Northern Division of the Lehigh Valley Railroad

and the Owego Division of the Delaware, Lackawanna and Western Railroad. It is a city of varied industries producing more than 60 distinct articles. There are 40 industries employing 4,505 people and having a capital investment of more than 22 million dollars. The Cortland area produces a large number of motor trucks, weaves one-fourth of the world's supply of wire cloth, and stands first in the United States in the manufacture of fish line. One of the newest industries is the making of corsets, the largest plant having accommodations for 1,000 employees. The industries which use large quantities of water have wells and with practically no exceptions obtain from them a satisfactory quantity of water of suitable quality to meet their requirements.

The incorporated villages of Homer and McGraw are contiguous to Cortland and form a part of its general business area. Homer, lying directly north of Cortland, was listed in the 1940 census as having a population of 2,921, of which an estimated 90 percent are served by the public water supply from wells. It, too, has a favorable location, at a junction of broad valley flood plains where Factory Creek flows into the West Branch of the Tioughnioga River. In 1945 there were eight industries in Homer, employing a total of 213 people. It is also served by the Delaware, Lackawanna and Western Railroad.

McGraw, with a population of 1,126, is about 4 miles east of Cortland, at the junetion of Smith and Trout Brooks. There

is a public water-supply system, used by about 98 percent of the residents and three of the five industries, which employ 300 people in all. The water is obtained from springs and wells.

Other nearby villages of local importance are Truxton, Preble, and Little York. These do not have public water supplies and creameries constitute practically the only industries.

The number of farms in the Cortland area is estimated to be considerably more than 1,000, and highly progressive methods of farming and dairying are used. The relative importance of dairying is shown by the number of large creameries from which water-supply data were obtained.

Climate

Climatic data were compiled from records of the U. S. Weather Bureau collected at the Cortland station over a 68-year period. The two most important climatic factors affecting ground water in the Cortland Quadrangle are precipitation and temperature. Both the amount and distribution of the precipitation and the changes in temperature are important in considering the recharge of the underground reservoirs and losses due to runoff, evaporation, and transpiration.

The mean annual precipitation is 37.92 inches. The total annual precipitation in relatively wet and dry years may be as much as 10 inches greater or less, respectively, than the mean annual precipitation. Records of actual monthly pre-

cipitation at East Homer during the years 1939-1945 (see pl. 2) shows that during these years the annual precipitation ranged from 32.06 to 46.84 inches. The greatest recorded annual precipitation at Cortland, 55.25 inches, fell in 1857 and the lowest, 29.39 inches, fell in 1934. From the graph of mean monthly precipitation (fig. 2) it may be noted that the greater part of the mean annual precipitation occurs during the summer months and the least amount during the winter months, the lowest mean monthly precipitation (2.08 inches) occurring in February and the highest (4.39 inches) in July. Approximately one-fourth of the total annual precipitation ordinarily occurs in the spring, when recharge conditions are most favorable.

The mean annual temperature is 45.7 degrees F., the greatest recorded deviations being +4.7 and -4.9. The absolute maximum and minimum recorded temperatures are 102 degrees F. and -30 degrees F., respectively.

The mean monthly temperatures as plotted in figure 2 show a range from a low of 22.7 degrees F. in February to a high of 68.6 degrees F. in July. Thus the highest mean monthly precipitation and temperature occur in the same month, and the same is true for the lowest. The winters last about 5 months and are moderately severe, and the summers are warm, with occasional short periods of high temperature. The average dates of the last killing frost in spring and the first in fall are about May 18 and October 2, respectively.

Although the above data were recorded at Cortland, only slight

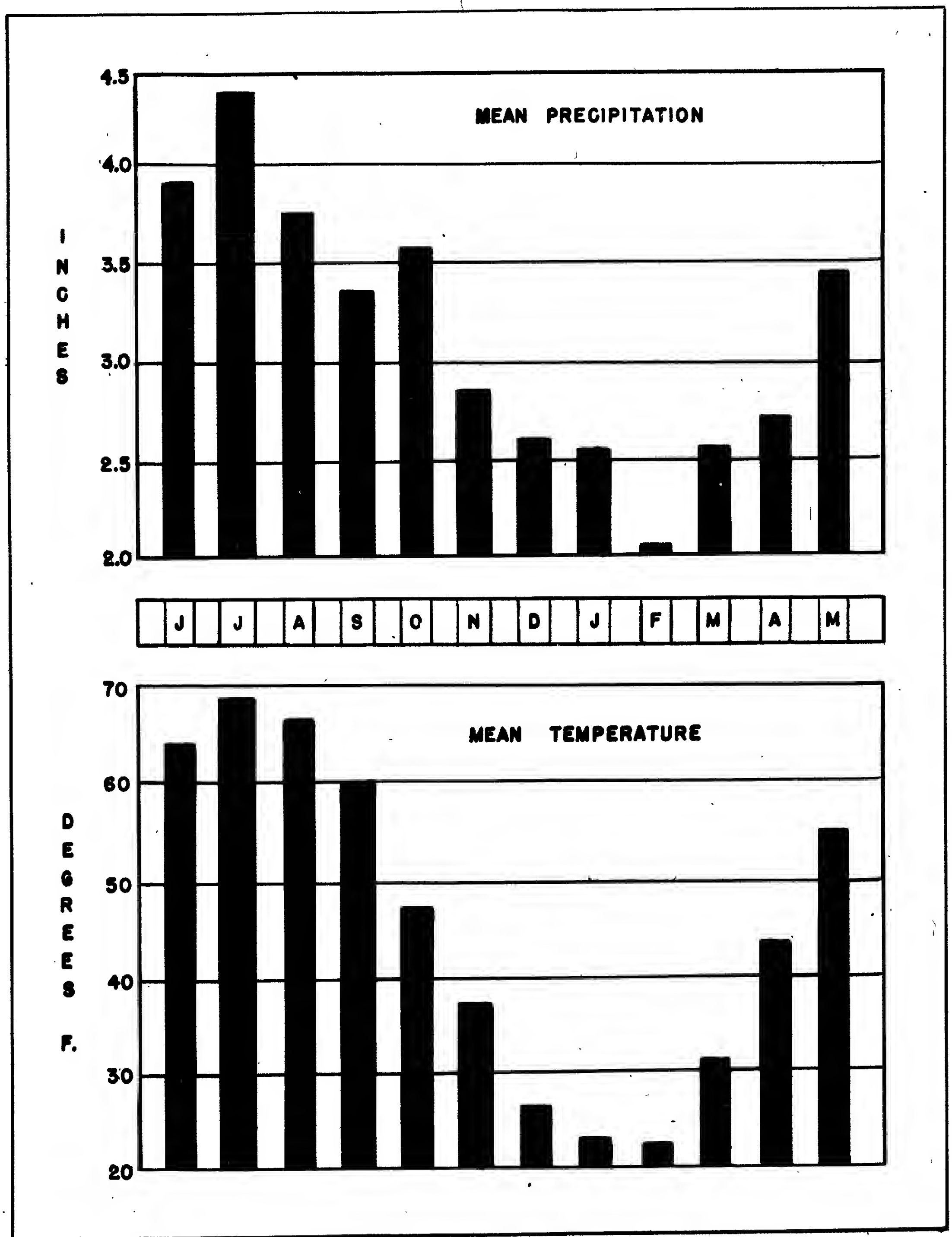


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FIGURE 2. MEAN MONTHLY PRECIPITATION AND TEMPERATURE AT CORTLAND, NEW YORK FOR THE PERIOD 1877 TO 1945. (TAKEN FROM CLIMATOLOGICAL DATA FOR NEW YORK STATE, U. S. WEATHER BUREAU).

variations would be expected throughout the quadrangle because of its limited areal extent and its moderate relief.

GEOLOGY

Devonian rocks

The bedrock formations exposed and those underlying the unconsolidated sediments throughout the Cortland quadrangle range from beds of the Hamilton group of Middle Devonian age, to and including beds of the Chemung formation, of Upper Devonian age. These rocks are shales and sandstones, with the exception of one limestone formation, the Tully limestone, in the lower part of the exposed geologic section. Because of changes in the conditions of deposition during Middle and Upper Devonian time, an increasing thickness of sandstone beds occurs toward the top of the section and toward the eastern part of the quadrangle. The rock strata are nearly horizontal, with an average regional dip to the south of about 40 feet per mile. Considerable variation in dip occurs in the southern part of the quadrangle. Because of the dip, beds successively younger in age are encountered in progressing from north to south. The coarser-grained deposits, therefore, crop out throughout the south and southeastern parts of the quadrangle, but they are restricted to the tops of the hills in the northern part. The valleys in the north are generally underlain by shales. The well-developed systems of joints in some of the more brittle beds probably provide channels in which ground water moves.

Pleistocene and Recent deposits

With the exception of a small amount of alluvium deposited by streams in Recent time, the unconsolidated material in the Cortland quadrangle was laid down during the Pleistocene epoch by the ice sheets or in streams and other bodies of water associated with the ice. Prior to Pleistocene time the Devonian rocks had been uplifted, eroded down to a nearly level surface, and again uplifted and partially dissected. The resulting topography, over which the Pleistocene ice sheet moved, greatly influenced the location and character of glacial erosion and deposition, and, therefore, it has an indirect but important bearing on the present occurrence of ground water in the glacial sediments in the area.

The location and direction of preglacial drainage in this and adjoining areas has not been fully determined. The most likely course of the preglacial Tioughnioga River was beneath the present stream valley in the northern half of the area and beneath the present drift-filled valley of Otter Creek in the southern half of the area. The greatest volume of the unconsolidated material in the Cortland quadrangle is concentrated along this course. According to Fairchild,[1/] the rock gorge of the Tioughnioga River, southeast of Cortland (pl. 1), is the location of the preglacial divide between the former course of the Tioughnioga and the headwaters of the preglacial streams to the southeast. The rock gorge contains very little sand and gravel. The maximum width of the valley flood plain is only a few hundred feet. Rock crops out in many places along the road through the valley and the wells located

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1/ Fairchild, H. L., The Susquehanna River in New York and evolution of western New York drainage: N. Y. State Museum Bull. 256, p. 85, 1925.

along the road enter rock within a few feet of the surface.

The resistant formations at the surface in most of the uplands in this quadrangle must have offered a considerable topographic barrier to the advance of the ice. Although at its greatest extension the glacier covered the plateau in a single mass, as indicated by the thin cover of drift distributed over the surface of the upland areas, it is believed that the ice began to leave the divides relatively early in the waning stages of glaciation. The drift or ground moraine on the uplands ranges in thickness from zero up to a few tens of feet, and it generally is thinner on the ridges than in the upland valleys. This veneer of glacial till ranges in grain size from silt to cobbles with a few large boulders. The character of the material shows that it was derived mostly from the local sandstones and shales, but it does contain a small percentage of fragments of igneous rocks and limestone, brought in from the north.

The most pronounced effects of ice erosion and deposition seem to have been concentrated in the valleys. The ice remained in the valleys in the form of lobes extending out from the main mass, after it had melted. Also, the ice had previously been thicker in the valley areas and, therefore, had a greater erosive power than on the uplands. According to Von Engeln,[2] lobes of the

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2/ Von Engeln, O. D., Effects of continental glaciation on agriculture: Am. Geog. Soc. Bull. vol. 46, p. 260, 1914.

southward-moving ice and their associated proglacial streams deepened the preglacial valleys to a considerable extent. When the ice front receded to the present site of Tully, just north of the Cortland quadrangle, it remained stationary for a long time, as evidenced by the large moraine built there. While the ice front remained stationary great amounts of material were washed forward by melting waters and distributed to the south. Overloaded streams carried the outwash into the valleys of the Tioughnioga River, filling them with beds of roughly sorted gravel, sand, and silt. In most places the depth to which the broad valleys are filled with unconsolidated deposits is not known. In the central parts of the valley of the West Branch the minimum thickness is estimated to be at least 200 feet and is probably considerably more. At Cortland, well C 40, which has a depth of 296 feet, is reported to have encountered rock, but the well is near the valley wall. All other existing wells in the center of the valley are relatively shallow except wells C 16 and C 35, which are 185 and 155 feet deep, respectively, and do not enter bedrock. No deep wells occur in the center of the valleys in the northern half of the quadrangle. The deepest of these wells north of Cortland is well C 60, located at Homer. It is 72 feet deep and does not enter bedrock. The sand and gravel deposits continue eastward from Cortland into the valley of Trout Brook. At McGraw well C 29 shows the gravels to extend to depths of at least 80 feet. East of McGraw rock is encountered in wells at depths of less than 80 feet, and in the vicinity of Solon the

depth is about 60 feet or less. The deepest well in the valley of Otter Creek southwest of Cortland shows 90 feet of gravels.

Von Engeln[3] has noted how the West Branch of the Tioughnioga River has been forced against the east wall of its valley by superimposed outwash fanning out from two tributary valleys, one at Preble and the other at Homer. He concluded that after the outwash from the Tully lobe of the ice sheet had been built up to its maximum level, heavy outwash deposits were still being brought out of the Otisco and Skaneateles Valleys and dumped on top of the Tully outwash plain. Therefore, the total thickness of outwash deposits in the broad valleys would probably be greatest at their junctions. It will be seen from an inspection of the logs listed in table 3 that the outwash in most places occurs in distinct beds, sometimes of considerable thickness. Furthermore, it is indicated that most of the beds are interconnected and consist of sand and gravel which have a fair degree of sorting. Interspersed among these are beds of clay and silt. The fine material, in places, occurs in lenses which thin rapidly and can be traced for only short distances. Their spotty occurrence indicates deposition in bodies of still water ponded in small depressions, some of which may have been caused by the melting of buried ice blocks in outwash material. Little York Lake, in the northern part of the Cortland quadrangle, occupies a depression which was formed in this way.

3/ Von Engeln, O. D., The Tully glacial series: N. Y. State Museum Bull. 227-228, p. 59, 1919.

The logs for wells in the city of Cortland show two gravel beds, each about 50 feet thick, which are separated by about 100 feet of finer material, consisting mainly of sandy silt. In the Homer area the situation seems to be the reverse. The finer-grained material lies at depths of about 30 feet and 70 feet, with gravel between these limits. These generalizations are only approximate because of the variation in thickness and character in the beds of outwash.

The three valleys in the northeast part of the quadrangle probably had a history similar in relation to glacial erosion and deposition to that of the valleys in the western part of the quadrangle. These six valleys, which have broad, gently sloping floors formed by deepening and subsequent deposition by the glacier or glacial streams, exercise almost complete control over existing drainage rather than being themselves controlled by it.

Since the end of the Pleistocene epoch narrow belts of modern flood-plain alluvium have been deposited along the existing streams. In contrast to the outwash deposits, the alluvium is not an important source of ground water because of its limited extent.

GROUND WATER

Source

The ground water in the Cortland quadrangle is derived chiefly from precipitation on the area which percolates downward to the zone of saturation. The proportion of rain and snow that reaches the water table ranges considerably throughout the quadrangle. The runoff from the upland areas is large because of the rolling topography and the thin cover of relatively impermeable soils. In contrast, the broad valleys, with their thick deposits of permeable outwash sand and gravel, absorb a large part of the precipitation.

Occurrence

Below the water table all the rocks are saturated, all the voids being filled with ground water. The quantity of water stored in a rock depends upon the percentage of open spaces or voids within it. However, only a part of the water stored in any rock may be recovered. The amount that may be recovered by pumping or other means depends chiefly upon the size, shape, and arrangement of the pore spaces and other openings. Accordingly, the character of the rocks in a region is of great importance in considering ground-water conditions.

In the Cortland area the bedrock consists chiefly of shales and sandstones that are well indurated and contain few pore spaces. In these rocks the opportunity for storage and movement of water is limited to joints, bedding planes, and other fracture openings. The volume of such openings, which diminish in number and size with depth, is relatively small in comparison with the volume of bedrock. Thus, the bedrock formations in the area generally do not furnish large

quantities of ground water to wells and springs. Even the sandstones are usually well cemented and yield relatively small quantities of water.

In contrast, the unconsolidated deposits in the area are highly porous and store large quantities of water. However, some of them--such as clays, silts, and till-consist of finely divided material and will not readily yield water to wells and springs. The coarser-grained materials, however, are highly permeable and are capable of furnishing large quantities of ground water. The coarse outwash deposits of sand and gravel are, therefore, the best sources of ground water in the Cortland area. Deposits of these materials, interbedded with layers and lenses of clay and silt, occur throughout the broad valleys and almost everywhere are capable of yielding large quantities of water.

Although all sands and gravels yield water, their relative value as sources of water supply depends in large part on the size and degree of assortment of their constituent particles. The character and consequently the permeability of the outwash deposits differs considerably from place to place. For example, the outwash is coarsest in the northern part of the quadrangle, near the Tully moraine, and generally becomes progressively finer downstream, toward the south. In addition, the degree of sorting and the coraseness of the sand and gravel beds at given localities varies with depth. Superimposed outwash from tributary valleys may be more permeable or less permeable than the underlying older outwash. Because of these features, the yields of wells which penetrate the outwash may range within wide limits. Nevertheless, even the least permeable outwash in the area appears to

be capable of furnishing large supplies of ground water.

The uplands are mantled with varying thicknesses of glacial till, sometimes called "boulder clay" because it consists chiefly of a clay matrix in which fragments of rock ranging in size up to boulders are imbedded. Because till is an unassorted material it has a much lower permeability and yield than outwash gravels, but it can furnish small perennial water supplies where it is of sufficient thickness. The upland valleys, in places, contain localized till deposits of considerable thickness. In these localities many dug wells utilize till beds as a source of domestic supply.

Throughout much of the area ground water occurs under water-table conditions; that is, the water is not confined beneath clay beds under artesian pressure. Clay beds of considerable thickness were encountered during the drilling of several wells in the valley areas (see table 3). These clay beds appear to be lenticular and of insufficient areal extent to produce artesian conditions. However, one of the rock wells, well C 28, has a slight flow at the land surface. This is the only indication discovered of artesian conditions in either the consolidated or the unconsolidated sediments.

The water table

The surface below which the ground is saturated with water under hydrostatic pressure is called the water table. Ground water moves in the direction of the slope of this surface, which in the Cortland quadrangle and generally elsewhere is from the uplands toward the valleys. The water table intersects the land surface at streams and lakes and is closer to the surface in the valleys than in the uplands.

General information was obtained about water levels in six wells in the uplands. All end in rock with the exception of observation well C 72, discussed below. The average water level in these wells was found to be about 44 feet below the land surface, the range in depth to water being from 3 feet to 90 feet below the land surface. Water-level data were also obtained for 49 wells in the valley areas. The average water level in these wells was about 11 feet below the land surface, the maximum depth being 35 feet.

In valleys where the water table slopes toward a stream channel, ground water supplements stream flow and the seepage is said to be effluent. Where the water table slopes away from a stream channel, water may pass from the stream into the ground and the seepage is said to be influent. During most of the year ground water feeds the streams in the Cortland area. However, during periods in the spring when the streams are at very high stages, considerable quantities of water percolate into the underground reservoirs from the larger streams.

The position of the water table is constantly changing. This fluctuation can be easily observed in wells and may furnish valuable information about ground-water conditions. The U. S. Geological Survey in cooperation with the New York State Department of Conservation maintains an observation well (well C 72) about 2½ miles north of East Homer. Information pertaining to the construction of the well is given in table 3. It is the only well in the Cortland quadrangle for which systematic and detailed observations are available.

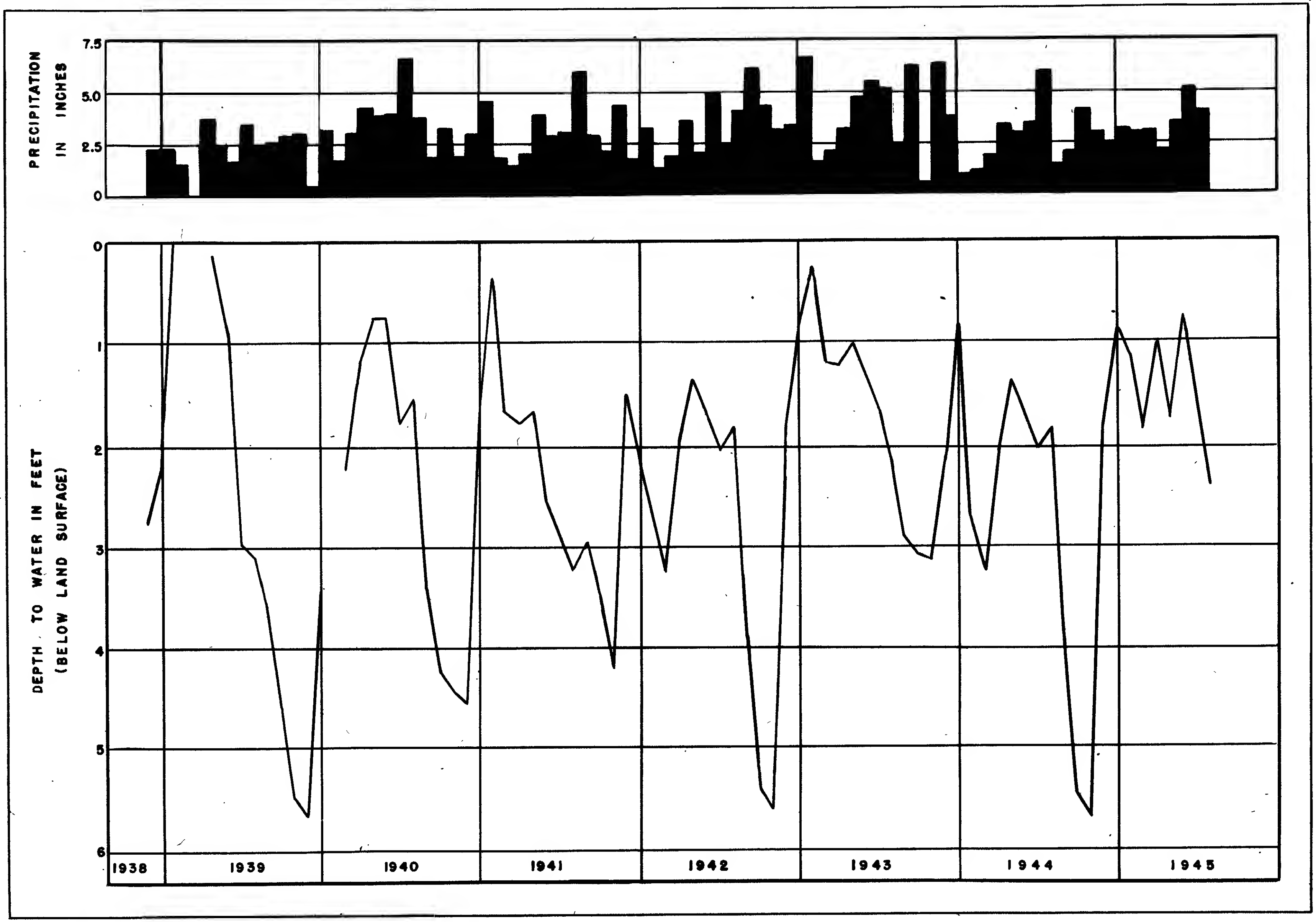
Observations of water level in this well were begun in October 1938. The well is equipped with an automatic water-stage recorder,

but only monthly observations were used in constructing the hydrograph shown in plate 2. There is no ground-water pumpage in the vicinity of the observation well, and all the fluctuations of the water level result from natural causes. The fluctuations of water level in this well are determined not only by the amount and distribution of precipitation but also by seasonal changes in the amount of water used by vegetation. This is shown by the marked decline in water level each year during the late spring, summer, and early fall, when the vegetation draws heavily upon the underground reservoir. The decline takes place in spite of the fact that the maximum precipitation occurs during the growing season (fig. 2). The effect of vegetal growth is further shown by the sharp rise in water level near the end of each year when consumption of water by vegetation ceases. These rises occur even though the average rate of precipitation is then rapidly decreasing. Evaporation is also a contributing agent along with plant transpiration, as both processes are most effective during periods of high temperatures and sunny weather and least effective at low temperatures.

Although the relationship between precipitation and water level is not a simple one, a comparison of the two graphs in plate 2 shows distinct correlation. Some of the most noticeable effects of increases in rate of precipitation are the reverses in the downward trend of the water-level graph for June 1940, July 1941, and June 1944. Observation well C 72 penetrates a shallow aquifer which is not contiguous with the outwash beds in the valley areas. Accordingly, the day-by-day fluctuation of the water table in the two areas may be quite dis-

PLATE 2

GROUND WATER LEVEL AND PRECIPITATION AT EAST HOMER, NEW YORK (WELL NO. C 72) 1938-1945.



similar. On the other hand, it appears probable that the general trend of water levels from year to year, where not affected by heavy pumpage, is similar.

Careful observations of water levels in wells in the broad valley areas have not been carried on, but a limited amount of information has been collected. It has been reported that no progressive lowering of water levels has occurred and that during the winter months the water table rises within a few feet of the land surface. It is also reported that water levels in the vicinity of heavily pumped wells recover rapidly after withdrawals cease.

Quality of Water

The amounts of the various chemical constituents present in ground waters largely determine their suitability for industrial, agricultural, and domestic uses (excluding sanitary considerations). Knowledge of the amounts of the different chemical constituents often aids in correlating geologic relationships. Water samples were collected from a number of wells, including those of the three public supplies, and were analyzed by the New York State Department of Health in Albany. The results are presented in table 1.

The total-solids content of the well waters that have been sampled ranges from 156 to 341 parts per million, the average being about 225 parts per million. This is considerably under the limits of tolerance for most uses. Water containing less than 500 parts per million of total dissolved solids is generally satisfactory for domestic use, unless there is difficulty with hardness, iron content, or corrosiveness. Nearly all the industries in the area utilize ground water extensively for low-pressure process steam. There appears to be no marked difference in total dissolved solids between waters obtained from the gravel and those from bedrock aquifers. Further, the averages of total dissolved solids for shallow rock wells and deep rock wells were approximately the same. There was only a slight increase with increasing depth. This increase perhaps is not significant, in view of the relatively great variation among the individual wells, especially the deeper rock wells.

The waters tested showed a minimum total hardness of 80 parts per million, a maximum total hardness of 280 parts per million, and

Table 1.—Analyses of Water from Wells in the Cortland quadrangle
Analyses by New York State Department of Health. Dissolved constituents given in parts per million.

Well No.	Depth in feet	Kind of water-bearing material	Date of collection	Total dissolved solids	Iron (Fe)	Manganese (Mn)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness (calculated as $CaCO_3$) Total	Carbonate	Noncarbonate	pH
C 5	300	Shale	12/7/45	157	0.4	0.015	155	12	11	92	92a	0	7.5
C 14	30	Gravel	12/6/45	203	.03	.01	156	33	3.8	176	128	48	7.5
C 16	184	do	12/7/45	192	.2	.15	161	31	3.0	160	132	28	7.5
C 18	18	do	12/6/45	193	.05	.01	165	15	3.0	144	135	9	7.5
C 25	85	Rock	7/2/46	205	.03	--	40	33	6.0	88	33	55	7.0
C 43	125	do	do	193	.07	.01	142	3.6	2.2	140	116	24	7.6
C 60	72	Gravel	12/6/45	164	.08	.01	149	15	1.8	136	122	14	7.7
C 62	40	do	do	337	.03	.01	244	35	10	260	200	60	7.5
C 63	35	do	do	341	2.3	.015	256	34	9.4	280	210	70	7.5
C 78	130	Rock	7/2/45	318	0.1	.03	190	6.1	21	80	80b	0	8.0
C 80	308	do	do	318	.03	--	179	4.3	80	80	80c	0	7.8
C 90	40	Gravel	12/7/45	251	.15	.01	167	28	30	152	137	15	7.7
C 92	169	Rock	do	242	.2	.025	204	21	30	124	124d	0	7.7
C 94	187	do	7/2/45	181	.03	.05	145	33	3.4	140	119	21	7.4
C 95	212	do	do	156	.1	.01	133	23	3.4	104	104e	0	7.8

a. Total alkalinity 127 parts per million, excess alkalinity 35 parts per million, as $CaCO_3$.
b. " " 156 " " " , " " 76 " " " , " " .
c. " " 147 " " " , " " 67 " " " , " " .
d. " " 167 " " " , " " 43 " " " , " " .
e. " " 109 " " " , " " 5 " " " , " " .

an average hardness of about 145 parts per million. The total hardness of the water from wells ending in gravel averages about 185 parts per million, 80 parts per million higher than that of water from the rock wells. Also, the upper limit of hardness of the water from wells in rock was 140 parts per million, which was approximately the same as the lower limit for the wells in gravel. Water from the rock wells does not show any marked differences in hardness with depth, 36 parts per million being the greatest variation from the average.

Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but the consumption of soap is slightly increased and the reduction of hardness by a softening process is profitable for such industries as laundries. Waters in the upper part of this range of hardness may cause considerable scale in steam boilers and treatment is often necessary. Hardness of more than 150 parts per million is readily noticed and it is a common practice to soften water, even for household use, where the hardness is 200 to 300 parts per million or more.

Hardness is caused by the presence of calcium and magnesium. These elements are also the active agents in the formation of scale in steam boilers. Calcium and magnesium may be combined with bicarbonate, which is the chief cause of alkalinity, to form carbonate hardness. In this case a soft scale of calcium and magnesium is formed. Calcium and magnesium carbonates may also be combined with the sulfates and other noncarbonate anions to form noncarbonate hardness, which induces a hard scale that is not easily removed. Sulfates were not present in particularly large quantities in the Cortland

samples. This is fortunate because the presence of sulfates is generally detrimental and often increases the cost of softening hard water.

In 10 of the 15 samples, whose analyses are shown in table 1, the hardness exceeds the alkalinity, but always by relatively small amounts. These amounts represent the noncarbonate hardness. In the Cortland samples the noncarbonate hardness is mostly due to the sulfates. Hardness exceeded alkalinity in all the wells in gravel. Five of the eight wells in rock showed no noncarbonate hardness, the water having greater alkalinity than hardness. In the rock wells the proportion of alkalinity to hardness increased somewhat with depth.

Next to hardness, iron is the constituent which most often causes concern. It is relatively easy to remove for public supply purposes, but is frequently difficult to remove from small domestic supplies. Any amount greater than about 0.20 part per million may precipitate when exposed to the air. The most objectionable feature of iron-bearing waters is their tendency to cause stains. Further, the growth of iron bacteria in water of high iron content may clog pipes. However, the water from well C 63, which contained a relatively large amount of iron, was used in boilers with no apparent difficulty. Amounts of iron alone or iron and manganese combined in excess of 0.20 part per million in water used for food processing, baking, canning, laundering, and tanning may cause serious difficulties. For domestic use, an appreciable amount of iron may impart a disagreeable color or taste. Approximately the same concentration of

iron was found in wells ending in gravel and in rock. The deeper rock wells averaged about 0.2 of a part per million and the shallower rock wells about half that amount.

Chloride has little effect on the suitability of water for ordinary uses except when its concentration is high. Then it may affect industrial usage by increasing the corrosiveness of waters. Only one of the samples contained chloride in excess of 30 parts per million, and undoubtedly the chloride content is small throughout the area.

At intervals throughout the year, the owners of well C 14 made partial analyses in which hardness was measured with soap solution. The results obtained indicate that there is a seasonal variation in the amount of dissolved minerals, the smallest concentration occurring during periods of high water level and following periods of heavy precipitation. However, such variations amount to only a small part of the total dissolved minerals.

Temperature of water

The temperature of water is of great importance in connection with industrial uses involving cooling. The temperature of ground water, which is lower than that of surface water in the summer and is nearly constant, makes it very desirable for this purpose, especially in milk plants and for air conditioning.

The temperature of ground water is related to the mean annual air temperature and to the depth in the earth from which it comes. Thwaites[4/] reports, on the basis of studies in southern New York State,

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4/ Thwaites, F. T., Ground water supplies of Allegany State Park, 1932: N. Y. State Museum Circular 11, pp. 21-25, 1935.

that down to a depth of about 60 feet the temperature of the ground changes appreciably with the season, though there is some lag, but below 60 feet the temperature increases with depth and is not affected by the season. Collins 5/ notes that the annual range in temperature of the ground decreases rapidly in the first few feet of depth, with indications that at about 30 feet the annual range would not be more than 1 degree. For all practical purposes a ground-water supply at any depth from 20 to 200 feet may be considered to have a uniform temperature, about the same as the mean annual air temperature. At depths of more than 300 feet, an average rate of increase of 1 degree F. for each 50 to 100 feet of depth must be taken into account. The differences in the temperature of ground water with season and with depth are extremely small in comparison with the fluctuations in the temperature of surface waters. For example, the total range for the wells in table 3 for which reported temperature data were obtained is from 40 to 50 degrees F. The average of these temperatures lies between 46 and 48 degrees F., slightly higher than the mean annual air temperature of 45.7 degrees F.

5/ Collins, W. D., Temperature of water available for industrial use in the United States: U. S. Geol. Survey Water-Supply Paper 520-F, pp. 97-98, 1925.

Recovery

The total amount of ground water recovered daily in the Cortland quadrangle is estimated to be about 5 million gallons. Springs are numerous in parts of the quadrangle, but they generally yield only small quantities of water. Water is obtained chiefly from wells, both in bedrock and in unconsolidated sediments. The amount of water recovered from wells depends largely upon the type of well and the material in which the well is developed. Most of the work of the present ground-water investigation was carried on in the valley areas, where drilled and driven wells ending in sand and gravel predominate. Therefore, nearly all of the records in table 3 are for driven and drilled wells which penetrate unconsolidated materials. In the uplands ground water is commonly recovered through springs, shallow dug wells, and drilled wells in rock.

Springs. A few springs were found with moderate and dependable yields. Reported yields ranged from less than 100 gallons per day to a maximum of about 40,000 gallons per day. The flow may be considered to be perennial, as all springs canvassed were reported never to fail. In the smaller springs, the fluctuation in the flow is great, and during periods of drought the larger springs were reported to have a noticeable reduction in yield.

Springs are most common along the slopes of the large valleys. In many places there is a belt of seepage springs in a linear arrangement approximately where some of the Devonian formations outcrop. The water from these springs probably does not come from the

bedrock but moves by gravity through the till, along the contact between the till and the bedrock, and comes to the surface in places where the bedrock is near to the surface.

Most of the springs are used for domestic and livestock supplies. Several small public supplies obtain water from privately owned springs. Very few industries in this area use spring water.

Dug wells. In the Cortland quadrangle, recovery of ground water by dug wells is common only on farms where consumption is small. Dug wells are numerous in many parts of the uplands. They are particularly adapted for use in these areas, where till is the chief water-bearing material. They have an advantage over small-diameter driven or drilled wells because the unconsolidated formations, such as till, are not highly permeable. They are generally several feet in diameter and have a large seepage area and relatively large storage. Dug wells are difficult to construct to any great depth and are, therefore, practical only where the water table is relatively close to the surface. The water table may decline below the bottoms of shallow wells during periods of drought, and because of this they are not as dependable as deeper wells. Dug wells are especially subject to contamination from surface seepage, and protective measures should be taken against such contamination.

The greatest yield of any single dug wells investigated in the Cortland quadrangle is that of well C 18, which is the source of the public water supply for the city of Cortland. Well C 18 is in the valley of Otter Creek and taps highly permeable outwash gravels. It is pumped continuously at 1,875 gallons a minute and has a very

small resulting drawdown (table 2). The specific capacity of this well, on the basis of reported data, is approximately 702 gallons a minute per foot of drawdown.

Driven wells. Throughout the broad valleys, a large percentage of the wells are of the driven type. The existence of large numbers of driven wells indicate the ease with which ground-water supplies may be obtained at shallow depths in the valleys. Records for 35 drive-point wells used for domestic purposes show a range in depth from 10 to 34 feet and in diameter from $1\frac{1}{4}$ to 2 inches. Yields of only a few gallons a minute from these wells satisfy domestic requirements. Driven wells are used by many industries at both Homer and Cortland. That sufficient quantities of water can be obtained from driven wells for rather extensive industrial use indicates the permeable character of the beds of outwash at shallow depths in these localities. The driven wells used by industry are all approximately 30 feet deep and are of larger diameter than the domestic drive points. Yields, with continuous pumping, range up to 150 gallons a minute. The largest average daily withdrawal by any one industry is from driven wells, about 500,000 gallons a day from seven wells.

Drilled wells in consolidated rocks. Records were obtained for 17 wells drilled in rock, which in the uplands furnish only small supplies. Well C 5, one of the McGraw public water-supply wells, has the greatest yield of the upland rock wells. However, less than 50 gallons per minute is obtained when it is pumped continuously, and the resultant drawdown in water level is large (table 2). A few drilled wells in rock are scattered throughout

the large valleys, and most of these are situated along the periphery of the valleys. Several have a moderately large yield, probably because of recharge from the overlying glacial material. For example, wells C 94 and C 95 were reported to yield about 100 gallons per minute each, the largest yield from rock wells that were examined. Well C 43, which yields continuously about 60 gallons per minute, is the only drilled well in rock in use in the Cortland industrial area. Wells that are drilled through unconsolidated material overlying the bedrock are generally cased to bedrock, a steel casing 6 inches in diameter being used most commonly.

<u>Drilled wells in unconsolidated deposits</u>. Approximately half the wells for which records were collected end in outwash materials. They are used for industrial, domestic, and public water-supply purposes. In the immediate vicinity of Cortland, quantities of 80 gallons per minute or more are pumped from most of the drilled wells which penetrate sand and gravel, and nearly all of these are capable of furnishing larger supplies. They range in depth from 20 to 185 feet. In the valley of the West Branch at Homer and to the north as far as Preble, the average rate at which drilled wells in outwash are pumped is about 60 gallons per minute, and the maximum rate is 725 gallons per minute. Practically all are capable of much greater yields, including well C 60, which is the most productive drilled well in the area. A pumping test on well C 60, made at the time of drilling, probably gives a better indication of the potentialities of the aquifer than the daily pumpage shown in table 2. A pumping rate of 1,600 gallons per minute (nearly

three times the present demand) was maintained throughout the test. The water level is reported to have declined 3 feet in the first hour, with only a small additional drawdown during the next 36 hours.

At Truxton drilled wells average 40 to 65 feet in depth and are pumped at rates of about 30 gallons per minute. In the buried valley beneath Otter Creek beyond the Cortland city limits, there are a number of drilled wells that end in gravels and are equipped with small pumps. Only small quantities of water are needed on the farms located here. Therefore, the potentialities of this areaare not definitely known, but the fact that large supplies are obtained under similar geologic conditions elsewhere would seem to indicate that large supplies may be obtained here.

The safe recovery of a maximum amount of ground water from drilled wells in unconsolidated sediments is dependent, in part, upon the proper construction and development of the wells. The importance of well construction for large-scale production from sands and gravels has not been recognized until recently by well owners in the Cortland area. However, most of the drilled wells ending in gravel that have been put down in the last few years by industrial concerns are finished with screens, in contrast to the older wells, which have an open-end finish.

Utilization

Ground water is used chiefly for industrial, livestock, domestic, and public water-supply purposes in the Cortland quadrangle (table 4). The withdrawal from the industrial and public-supply wells examined in the towns of Cortland and Homer amounts to more

than 4 million gallons a day, which is about three-fourths of the total quantity of ground water withdrawn in the entire quadrangle.

Industrial supplies. The total quantity of water pumped daily by the large industrial concerns in the vicinity of Cortland, numbering about 12, is nearly 1 million gallons. This is equivalent to approximately 40 percent of the amount pumped for public supply. In the Homer area, the quantity of water pumped for industrial use is much smaller, being less than 150,000 gallons a day, equivalent to approximately 30 percent of the withdrawal for public supply. Most of the plants requiring water for processing prefer to utilize wells rather than purchase water from the public supply.

The industries which use ground water may be conveniently divided into two groups--heavy industries and light industries. The heavy industries were found to be much larger consumers. They include, for example, companies manufacturing airplane and automotive parts and wire products. Steel mills operated by these companies use relatively large quantities of ground water. One plant alone has a minimum daily withdrawal of at least half a million gallons. This is the largest production for any single industrial concern in the quadrangle. Two wells at another steel plant have a combined pumpage of about 150,000 gallons a day. One meat packing concern has three wells with a total average daily withdrawal of 190,000 gallons. Classed as light industries are such commercial organizations as creameries, canneries, restaurants, and garages. The canneries are heavy users of water but operate only a few months of each year. Records were obtained for 17 creamery wells in the

Cortland quadrangle. There are four creameries at Cortland, and they have a combined pumpage of about 95,000 gallons per day. In the Homer and Preble areas there are five creameries pumping a total of about 120,000 gallons per day. At two milk plants in the East Branch valley the combined daily withdrawal is estimated to be about 87,000 gallons.

Domestic and agricultural supplies. The demand for domestic use is less than that for the industrial supply. However, domestic wells far outnumber industrial wells. Domestic wells and those used for agricultural purposes constitute half the total of 97 wells for which data were obtained. Most of the wells and either in glacial till or in outwash gravels. Their rate of pumping is usually small, seldom more than a few gallons per minute. Many farms in the valley of the West Branch at Homer and to the north as far as Preble obtain supplies from springs on the valley slopes. Springs are the principal source supplying farms in the valley of the East Branch between Cortland and Truxton. On farms water is used primarily for livestock and as far as is known is not used for irrigation.

Public water supplies. The three largest communities in the area have public supplies which are dependent on ground water. Cortland and Homer obtain their water supplies exclusively from wells. McGraw utilizes wells during dry periods when the public-supply springs do not yield sufficient water. Although the McGraw installations are located in the uplands, they were included to complete the information on public water supply in the area. The villages of Preble and South Cortland also have small supplies. The average

yield and reported water levels for the larger public water-supply wells in the Cortland quadrangle are shown in table 2.

Table 2. Withdrawal of ground water for public supply in the Cortland area.

Location	Source	Average daily pumpage in gallons	Water level in feet below surface		Years used
			Average non-pumping	Average pumping	
Cortland	Dug well C 18	2,450,000	5.5	8.2	1910-1945
Homer	Drilled well C 60	406,000	9	12	1937-1945
McGraw	Drilled well C 6 and springs	50,000	25 a/	85 a/	1936-1945

a/ Well C 6.

The history of the public water supply at Cortland may be dated back to about 1882, when action was started by the village authorities toward granting a franchise for a waterworks. Agreements were reached with Hinds, Moffett, and Co., whose installations were valued at about $50,000. The supply was obtained from large springs on the East Branch of Otter Creek a mile from Main Street. Today the municipally-owned public water system is under the direction of a water board and has 125 acres of land in the same general vicinity along Otter Creek. The system, including 42 miles of water mains and storage capacity for 1 million gallons, is valued at $811,000. The source of supply is two large dug wells which penetrate gravel. Well C 18, the smaller of the two, yields sufficient water to satisfy the daily needs and maintains a more even pressure in the pumping

system than well C 19. Well C 19 has not been used since 1940 (table 3). At well C 18, the bedrock is approximately 17 feet below the bottom of the well or 35 feet below land surface. Water is pumped from an aquifer having extensive exposure at the land surface. Considering the large quantity of water pumped daily from the Cortland well, the average drawdown of only 2.7 feet is remarkable. The greatest monthly consumption occurs in the late summer and early fall, when the water table is normally at its lowest point. During the dry season of 1939, for example, the pumping level is reported to have been lowered to 12.3 feet below the land surface. During the spring the water level recovers and is near the surface. In December 1945 the total hardness of water pumped from well C 18 was 144 parts per million, and the total alkalinity was 135 parts per million. A more complete analysis is given in table 1.

The incorporated village of Homer invests authority for the operation of its water supply in a board of trustees. The supply is obtained from two drilled wells in gravel, well C 60 and well C 59 (table 3). Well C 59 actually consists of four wells connected to one delivery pipe. It is used as an auxiliary and has been pumped only occasionally since the completion of well C 60 in 1937. The Homer system has a storage capacity of 150,000 gallons, and pressure is maintained throughout by pumping. Its services are 100-percent metered. The water is not treated. An analysis of water collected from well C 60 during December 1945 showed a total hardness of 136 parts per million and an alkalinity of 122 parts per million. A more complete tabulation and interpretation of water

analyses is given in a preceding section of this report.

The village of McGraw has a municipally-owned water system based on wells and springs operated by a board of trustees. The water flows from the springs by gravity but must be pumped from the wells. The springs are used at times when they furnish a sufficient quantity of water. They do not have a deep-seated source but instead derive their supply from seepage near the surface, in close proximity to a brook. This water is treated by chlorination and slow sand filtration. There are two drilled wells, well C 5 and well C 6 (table 3). They are within a few feet of each other and are never used simultaneously. Both penetrate the same water-bearing formation, reported to be shale and slate rock with a thin bed of sandstone near the bottom of the wells. Well C 5 is maintained as an auxiliary and since 1936 has seldom been pumped. At times during dry seasons, well C 6 is used exclusive of the springs, but usually for short periods only. Several years ago it was necessary to pump from well C 6 for about 3 months, which resulted in a lowering of the water level to 170 feet below the surface. The average daily withdrawal shown in table 2 is the average quantity of water used throughout the year in the McGraw system and pertains to well C 6 only while it is being used to the exclusion of the other sources. It is probable that the capacity of the wells alone is not great enough to satisfy existing demands completely. An analysis of water pumped from well C 5 in December 1945, which is probably nearly identical in quality to water from well C 6, shows a total hardness of 92 parts per million and a total alkalinity of 137 parts per million. As may

be noted from table 1, the amount of iron present was 0.4 part per million. This is above the preferable limit for most uses. About 98 percent of the population use the public supply, and 95 percent of the services are metered. The storage capacity of the system is about 125,000 gallons. Three industrial plants in McGraw use the public supply entirely. Two other plants have private water supplies (wells C 29 and C 30). However, these plants have occasionally supplemented their own supplies with water obtained from the public system.

The small village of Preble has a cooperative water supply obtaining water from drilled well C 77 (table 3), which supplies about 15 families but does not serve any farms. There are no meters in the system, but it is estimated that the daily pumpage amounts to about 5,000 gallons.

The majority of families in South Cortland obtain their supply of water from a privately owned spring located on the hill about a mile east of the village. Water flows by gravity to the consumers from an elevation of 1,500 feet. The difference in elevation of about 300 feet results in sufficient pressure to meet needs adequately.

SUMMARY

The bedrock and the thin mantle of glacial till in the uplands have a relatively low permeability. However, they generally furnish adequate water supplies for domestic and livestock purposes and in places yield moderate quantities of water for industrial and public supply. The chief water-producing formations in the Cortland area are the sand and gravel deposits. These deposits occur throughout the broad valleys where the large demands for ground water exist. Approximately 3½ million gallons of water is recovered daily from the sands and gravels at the city of Cortland. This is 70 percent of the estimated total daily pumpage in the Cortland quadrangle. The limits of safe yield have not been reached even in the Cortland industrial area. The water table in the large valleys is within a few feet of the surface at most times during the year.

Analyses of water samples collected from wells in bedrock and unconsolidated deposits show relatively small amounts of dissolved mineral constituents. They also show that there is some increase in hardness and iron content with depth and that water from the gravels tends to have a greater noncarbonate hardness than water from the bedrock. However, the differences in the quality of ground water that was obtained from the different kinds of water-bearing formations and from different depths are very small. The low, constant temperature and the generally good quality of the water in the different geologic formations make the ground water suitable for a wide range of uses. In addition, the long record of substantial pumpage from several

wells in the sand and gravel deposits, including the Cortland public-supply wells, indicates that the economy of the area is dependent in considerable part on the availability of the ground-water supply.

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Table 3. Records of wells in the Cortland Quadrangle, Cortland County, New York.

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of water c/	Remarks
C 1	L. M. Garner 3/4 mile N. of Cortland	1100	DRV	25	2	Gravel	1/4 HP.		46	DOM	0 to 3 feet Soil Little Black Sand Remainder Gravel
C 2	Harold Head 1½ miles N. of Cortland	1120	DRL	90	-	Sand	1/2 HP.			DOM STO	0 to 25 feet Gravel 25 to 65 feet White Sand
C 3	John Ottenshot 2 miles NW of Cortland	1160	DRL	107	4	Rock	1 HP. 40 GPM			DOM STO	
C 4	J. C. Leach 2 miles NW of Cortland	1160	DRL	102	4	Rock	1 HP.			—	
C 5	McGraw Public Water Supply 2 miles N. of McGraw	1380	DRL	300	6	Shale	7½ HP. T 100 GPM	55	48	PWS	0 to 56 feet Hardpan 56 to 300 feet Shale and Slate
C 6	McGraw Public Water Supply 2 miles N. of McGraw	1380	DRL	300	12	Shale	7½ HP. T 100 GPM		48	PWS	0 to 56 feet Hardpan 56 to 300 feet Shale and Slate
C 7	Charles Boss 3 miles SW of Cortland	1200	DRV	30	1¼	Gravel	1/4 HP.		42	DOM STO	
C 8	Richard Space 2½ miles SW of Cortland	1180	DRL	80	6	Gravel	1 HP.			DOM	
C 9	D. Mason 2½ miles SW of Cortland	1200	DRL	50	6	Gravel	1/4 HP.			DOM	
C 10	Hubert Hull 2½ miles SW of Cortland	1180	DRL	60	6	Gravel	1/4 HP.			DOM	
C 11	Bill Bros. Dairy 2 miles SW of Cortland	1180	DRL	45	6	Gravel	1½ HP. 12 GPM	12	46	IND	
C 12	E. A. Besley 1½ miles SW of Cortland	1180	DRL	55	6	Gravel	1/4 HP. 4-1/3 GPM		50	DOM STO	
C 13	Steve Stull 1½ miles SW of Cortland	1180	DRL	90	6	Gravel	3/4 HP. 7 GPM		45	IND	
C 14	Wickwire Bros. Cortland	1120	DRV	30	6	Gravel		150		IND	One of several similar wells at this plant.
C 15	Beaudry Wall Paper Co. Cortland	1100	DRL	82	8	Gravel	275 GPM 25 HP. C	30		IND	
C 16	Brockway Motor Co. Cortland	1100	DRL	185	6	Gravel		30		IND	0 to 35 feet Gravel and Hardpan 35 to 130 feet Clay 130 to 185 feet Gravel

See footnotes at end of table.

19132.

Table 5. Records of wells in the Cortland Quadrangle, Cortland County, New York.

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of Water c/	Remarks
C 17	Cobaco Baking Co. Cortland	1120	DRL	105	8	Hardpan or Rock	5 HP. 50 GPM	50		IND	0 to 35 feet Gravel 35 to 96 feet Silt 96 to 105 feet Hardpan or Rock
C 18	Cortland Public Water Supply Cortland	1140	DUG	18	240	Gravel	200 HP. 1875 GPM	1875	46	PWS	
C 19	Cortland Public Water Supply Cortland	1140	DUG	18	624	Gravel			46	PWS	Well not used since 1940.
C 20	J. Jones 1½ miles E. of Cortland	1100	DRV	18	1½	Gravel	1/4 HP.			DOM	
C 21	F. V. Shearer ¾ mile E. of Cortland	1100	DRV	20	2	Gravel	1/4 HP.			DOM	0 to 5 feet Sand 5 to 8 feet Hardpan 8 to 11 feet Gravel
C 22	J. H. Grover 1½ miles E. of Cortland	1100	DRV	20	1½	Gravel	1/4 HP.			—	
C 23	D. B. Jordon 2 miles SE of Cortland	1100	DRV	22	1½	Gravel	1/4 HP.			DOM	
C 24	I. Bacon 2½ miles SE of Cortland	1120	DRL	98	6	Rock				STO	0 to 28 feet no record 28 to 98 feet Rock
C 25	O. W. Friedat 2½ miles SE of Cortland	1120	DRL	85	5	Rock	1/4 HP.		42	STO	15 to 85 feet Rock
C 26	I. Edwards 2-3/4 miles SE of Cortland	1120	DRL	158	6	Rock	1/4 HP. 5 GPM			DOM STO	0 to 24 feet no record 24 to 158 feet Rock
C 27	Bert Travis ½ mile W. of McGraw	1160	DRV	15	2	Gravel	S			DOM	0 to 4 feet Clay 4 to 15 feet Gravel
C 28	Mrs. S. K. Brown McGraw	1160	DRL	155	—	Rock	—		48	—	0 to 150 feet record missing 150 to 155 feet rock (quicksand at 60 feet)
C 29	Empire Corset Factory McGraw	1140	DRL	80	1½	Gravel	1 HP.		40	IND	
C 30	Central Paper Box Co. McGraw	1140	DRL	—	1-3/4	Shale	1/2 HP.			IND	
C 31	H. Wadesworth 1 mile E. of McGraw	1180	DRV	10	1½	Gravel	1/4 HP.			STO	
C 32	Mrs. Clara Stevens 1¼ miles E. of McGraw	1220	DUG	17	24	Gravel	S			STO	

See footnotes at end of table.

Table 3. Records of wells in the Cortland Quadrangle, Cortland County, New York

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of Water c/	Remarks
C 33	Lehigh R. R. Cortland	1140	DRV	28	18	Gravel	C 75 GPM	16	50	IND	
C 34	Halstead Canning Co. Cortland	1140	DRL	90	6	Gravel			40	IND	
C 35	Brewer Titchener Corp. Cortland	1120	DRL	155	6	Sand	T 75 GPM	75		IND	
C 36	Titchener Forging Division Cortland	1100	DRL	30	8	Gravel	100 GPM	100	45	IND	Another similar well at this plant.
C 37	Community Grill Cortland	1120	DRV	38	4	Gravel				IND	Well not used in several years.
C 38	Goodale Dairy Cortland	1120	DRL	40	8	Sand	85 GPM	85	48	IND	
C 39	Bordens Dairy Cortland	1120	DRL	20	4	Gravel			40	IND	
C 40	Bordens Dairy Cortland	1120	DRL	296	8	Rock	None		40	—	Well not used for several years. Reported to contain considerable sulphur.
C 41	P. D. Camp & Sons ½ mile W. of Cortland	1160	DRL	65	8	Gravel	T 150 GPM	150	46	IND	0 to 30 feet Soil and Hardpan 30 to 65 feet Gravel
C 42	P. D. Camp & Sons ½ mile W. of Cortland	1160	DRL	60	8	Gravel	T 100 GPM	100	46	IND	0 to 30 feet Soil and Hardpan 30 to 60 feet Gravel
C 43	P. D. Camp & Sons ½ mile W. of Cortland	1160	DRL	125	8	Rock	T 60 GPM	60	46	IND	0 to 30 feet Soil and Hardpan 30 to 75 feet Gravel 75 to 125 feet rock
C 44	Grand Union Slaughter Co. Blodgett Mills	1080	DRL	40	6	Sand	50 GPM		45	IND	
C 45	Cosmos Hill Dairy 2 miles NW of Cortland	1500	DRL	155	6	Rock	50 GPM			IND	
C 46	Abadalah Dairy Cortland	1160	DRL	69	8	Sand	40 GPM	40	48	IND	Finished with 5 feet of well screen.

See footnotes at end of table.

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Table 3. Records of wells in the Cortland Quadrangle, Cortland County, New York

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of Water c/	Remarks
C 47	Mrs. L. Kirk 2 miles E. of Homer	1120	DRV	40	2	Gravel	1/4 HP.		42	STO	0 to 20 feet Gravel 20 to 23 feet Hardpan 23 to 27 feet Gravel
C 48	Russell Parker 4½ miles NE of Homer	1120	DUG	18	—	Gravel	1/4 HP.			DOM	
C 49	Lester Knapp 5 miles N. of Homer	1180	DRV	20	1½	Gravel	1/4 HP.		42	DOM	
C 50	Smith Wright 4 miles N. of Homer	1160	DRV	24	1½	Gravel	1/4 HP.			DOM	
C 51	G. Neuman 4 miles N. of Homer	1160	DRV	22	1½	Gravel	4 GPM		50	DOM	
C 52	L. G. Gallup 3½ miles N. of Homer	1160	DRV	22	1½	Gravel	1/3 HP.			DOM	
C 53	B. Chapman 3 miles N. of Homer	1140	DRV	19	1½	Gravel	S			DOM	
C 54	Ralph Davis 3 miles N. of Homer	1140	DRV	20	1½	Gravel	1/4 HP.		45	DOM	
C 55	M. G. Shuttis 2 miles N. of Homer	1140	DRV	17	—	Gravel	1/4 HP.			DOM	
C 56	Claude Stanton 1½ miles N. of Homer	1140	DRV	25	1½	Gravel	1/4 HP.		50	DOM	
C 57	F. R. Elbridge 1 mile N. of Homer	1120	DRV	26	1½	Gravel	1/4 HP.			DOM	
C 58	William Lewis Homer	1120	DRV	—	1½	Gravel	1/4 HP. 4-1/3 GPM			DOM	
C 59	Homer Public Water Supply Homer	1140	DRL	65	6	Gravel	S 60 HP.		48	PWS	Consists of four wells connected to one intake pipe. Auxiliary supply used occasionally.
C 60	Homer Public Water Supply Homer	1140	DRL	72	12	Black sand and gravel	730 GPM	725	48	PWS	0 to 35 feet soil and clay 35 to 56 feet gravel, clay and loam 56 to 72 feet black sand and gravel Finished with 15 feet of well screen
C 61	Dairymen's League Coop. Assn. Homer	1140	DRV	30	6	Gravel	5 HP. 200 GPM	60	46	IND	Another similar well at this plant
C 62	Sheffield Farms Homer	1140	DRL	40	8	Gravel			48	IND	

See footnotes at end of table.

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Table 3. Records of wells in the Cortland Quadrangle, Cortland County, New York.

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of Water c/	Remarks
C 63	David Harum Canning Co. Homer	1140	DRL	35	12	Gravel	25 HP. 250 GPM	150	48	IND	Well drilled to 80 feet then casing pulled back to about 35 feet.
C 64	David Harum Canning Co. Homer	1140	DRV	20	6	Gravel	60 GPM	40	48	IND	Another well at this plant not used in 1945.
C 65	Dairymen's League Coop. Assn. ½ mile E. of Little York	1160	DRL	40	—	Gravel	60 GPM	60		IND	Two other similar wells at this plant for auxiliary supply, seldom used.
C 66	Woolwear Co. Homer	1140	DRL	35	4	Gravel	52 GPM	10		IND	Open-end finish, no screen.
C 67	Homer Laundry Homer	1120	DRV	33	1½	Gravel	22 GPM	22		IND	
C 68	L. O. Andersen 3½ miles NW of Homer	1260	DRV	25	1½	Gravel				DOM	
C 69	Brown Dairy Homer	1120	DRL	40	8	Gravel	none				0 to 20 feet Sand 20 to 40 feet Gravel Finished with 6 foot well strainer. Water level 3 feet below land surface 1945
C 70	Brown Dairy Homer	1120	DRV	26	1½	Gravel	17 GPM	15		IND	Open-end finish, no screen.
C 71	Fairview Camp Assn. 2 miles N. of Homer	1200	DRL	180	6	Rock				DOM	Approximately 100 feet to rock. Well in use two months each year.
C 72	N.Y.State Conservation Dept. 2½ miles N. of East Homer	1500	DUG	10	18	Gravel	—			OBS	U. S. Geological Survey observation well. d/
C 73	L. Steger 6 miles NE of Homer	1200	DRV	—	1½	Gravel	—			DOM	
C 74	LeRoy Rofe 1 mile SE of Preble	1180	DRV	18	1½	Gravel	6 GPM 1/4 HP. C		50	STO	
C 75	John Mahan 1 mile E. of Preble	1200	DRV	24	1½	Gravel	1/4 HP. C 4 GPM		50	DOM	
C 76	Preble Milk Co. Preble	1180	DRL	47	8	Gravel	110 GPM T	110	48	IND	
C 77	Preble Water Supply Corp. Preble	1220	DRL	59	6	Gravel	13 GPM		45	DOM	
C 78	John Winchester Scott	1400	DRL	130	6	Rock				STO	0 to 14 feet Soil 14 to 130 feet Rock

See footnotes at end of table.

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Table 3. Records of wells in the Cortland Quadrangle, Cortland County, New York.

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F.	Use of Water c/	Remarks
C 79	Clayton Fisk 1½ miles W. of Solon	1320	DRL	72	6	Sand	1/4 HP.			STO	
C 80	E. B. Brickford 1/5 mile W. of Solon	1320	DRL	308	6	Rock	1/4 HP.		46	DOM STO	
C 81	L. B. Marion Solon	1320	DRV	22	1½	Quicksand	1/4 HP.			DOM	
C 82	C. H. Thornton & Son 1/5 mile SE of Solon	1320	DRV	17	1½	Gravel	1/4 HP.			DOM	
C 83	C. H. Thornton & Son 1/5 mile SE of Solon	1300	DRL	65	5	Rock			40	DOM	Well not used since June, 1946.
C 84	C. Vincent Truxton	1160	DRL	65	6	Gravel	1/4 HP.			DOM	
C 85	Mrs. Otto Miller Truxton	1200	DRL	50	6	Gravel			41	DOM	
C 86	N. R. Comefort Truxton	1180	DRL	50	6	Gravel	1/4 HP.		40	DOM	
C 87	A. E. French Truxton	1160	DRV	42	2	Gravel				DOM	
C 88	J. J. Meddrim Truxton	1160	DRV	42	1½	Gravel				DOM	
C 89	Charles Graham Truxton	1160	DRV	24	2	Sand and Gravel			45	DOM	
C 90	Sheffield Farms Truxton	1160	DRL	40	6	Gravel	50 GPM	50	46	IND	
C 91	C. McCall 2 miles S. of Truxton	1200	DRL	70	6	Rock	1/2 HP.		46	STO DOM	
C 92	Truxton Central School Truxton	1250	DRL	169	8	Rock		25		DOM	66 to 169 feet Rock.
C 93	Truxton Central School Truxton	1250	DRL	161	8	Rock	None			—	66 to 161 feet Rock.

See footnotes at end of table.

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Table 5. Records of wells in the Cortland Quadrangle, Cortland County, New York.

Well No.	Owner and Location	Altitude above sea level in feet	Type of well a/	Depth in feet	Diameter in inches	Principal Water-bearing Material	Type and Capacity of Pump b/	Yield in gallons a minute	Temperature in degrees F	Use of Water c/	Remarks
C 94	Hegeman Farms Cooperative 5½ miles SW of Truxton	1220	DRL	187	—	Rock	150 GPM	100		IND	62 to 187 feet Rock
C 95	Hegeman Farms Cooperative 5¼ miles SW of Truxton	1220	DRL	212	—	Rock	150 GPM	100		IND	62 to 212 feet Rock
C 96	R. M. Buston 4 miles SW of Cortland	1280	DRL	50	6	Gravel	1/2 HP.			DOM STO	
C 97	Otto Vogt 7 miles SE of Cortland	1060	DRV	34	1¼	Gravel	1/4 HP. 4 GPM			DOM	

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a/ Type of well: DRV, driven; DRL, drilled.

b/ HP, horsepower, GPM, gallons per minute. Type of pump: C, centrifugal, S, suction, T, turbine.

c/ Use of water: DOM, domestic; IND, industrial; OBS, observation; PWS, public water supply, STO, stock.

d/ Designated in Geological Survey Water-Supply Papers 845, 886, 906, 956, 944 as East Homer Creek Well 1. Current measurements on file at the offices of the U. S. Geological Survey, Surface Water Division, Ithaca, New York. See Plate 2.